

# **Unit 7**

## **Evolution**

### **Chapter 19: Descent with Modification**

# Overview: Endless Forms Most Beautiful

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- This unit will focus on three key observations about life
  - The fit between organisms and their environment
  - The shared characteristics (unity) of life
  - The diversity of life

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- A new era of biology began in 1859 when Charles Darwin published *The Origin of Species*
    - *The Origin of Species* focused biologists' attention on the great diversity of organisms
  - Darwin noted that current species are descendants of ancestral species
  - **Evolution** can be defined by Darwin's phrase *descent with modification*
    - Change over time
  - Evolution can be viewed as both a pattern and a process

## Concept 19.1: The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species

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- Carolus Linnaeus was the founder of taxonomy
  - The branch of biology concerned with classifying organisms
- He developed the binomial format for naming species (for example, *Homo sapiens*)

# Ideas About Change over Time

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- The study of **fossils** helped to lay the groundwork for Darwin's ideas
  - Fossils are remains or traces of organisms from the past
  - Usually found in sedimentary rock, which appears in layers or **strata**
- **Paleontology**, the study of fossils, was largely developed by French scientist Georges Cuvier
  - He noted that the older the stratum, the more dissimilar its fossils were to current life-forms
  - From one layer to the next, some new species appeared while others disappeared
  - He speculated that each boundary between strata represents a catastrophe that destroyed many species

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- Geologists James Hutton and Charles Lyell perceived that changes in Earth's surface can result from slow, continuous actions still operating today
  - Lyell further proposed that the mechanisms of change are constant over time
  - This view strongly influenced Darwin's thinking

# Lamarck's Hypothesis of Evolution

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- Lamarck hypothesized that species evolve through
  - Use and disuse of body parts
  - Inheritance of acquired characteristics
- The mechanisms he proposed are unsupported by evidence!
  - Acquired traits CANNOT be inherited!
- But he did recognize that the match of organisms to their environments can be explained by gradual evolutionary change

## Concept 19.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life

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- During his travels on the *Beagle*, Darwin collected specimens of South American plants and animals
- He observed that fossils resembled living species from the same region, and living species resembled other species from nearby regions
- Darwin was influenced by Lyell's *Principles of Geology*
  - Observations of fossils and their locations led him to agree that Earth was more than a few thousand years old
- He hypothesized that species from South America had colonized the Galápagos and diversified on the islands, giving rise to new species



# *Darwin's Focus on Adaptation*

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- Darwin observed many examples of **adaptations**
  - Inherited characteristics that enhance their survival and reproduction in specific environments
- In reassessing his observations, Darwin perceived adaptations to the environment and the origin of new species as closely related processes

(a) Cactus-eater



(b) Seed-eater



(c) Insect-eater



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- **Natural selection** is a process in which individuals with favorable inherited traits are more likely to survive and reproduce
  - In 1844, Darwin wrote an essay on natural selection as the mechanism of descent with modification
    - In June 1858, Darwin received a manuscript from Alfred Russell Wallace, who had developed a theory of natural selection similar to Darwin's
    - Darwin quickly finished *The Origin of Species* and published it the next year

# Ideas from *The Origin of Species*

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- Darwin explained three broad observations about life
  1. The unity of life
  2. The diversity of life
  3. The match between organisms and their environment

# *Descent with Modification*

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- Darwin never used the word *evolution* in the first edition of *The Origin of Species*
- The phrase *descent with modification* summarized Darwin's perception of the unity of life
  - Organisms share many characteristics
  - Believed that all organisms are related through descent from an ancestor that lived in the remote past
  - They accumulated diverse modifications, or adaptations, that fit them to specific ways of life

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- In the Darwinian view, the history of life is like a tree with a common trunk and branches representing life's diversity
    - Each fork of the tree represents the most recent common ancestor to its branches
  - Fossils of extinct species help to “fill in” the morphological gaps between present-day groups
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Figure 19.8

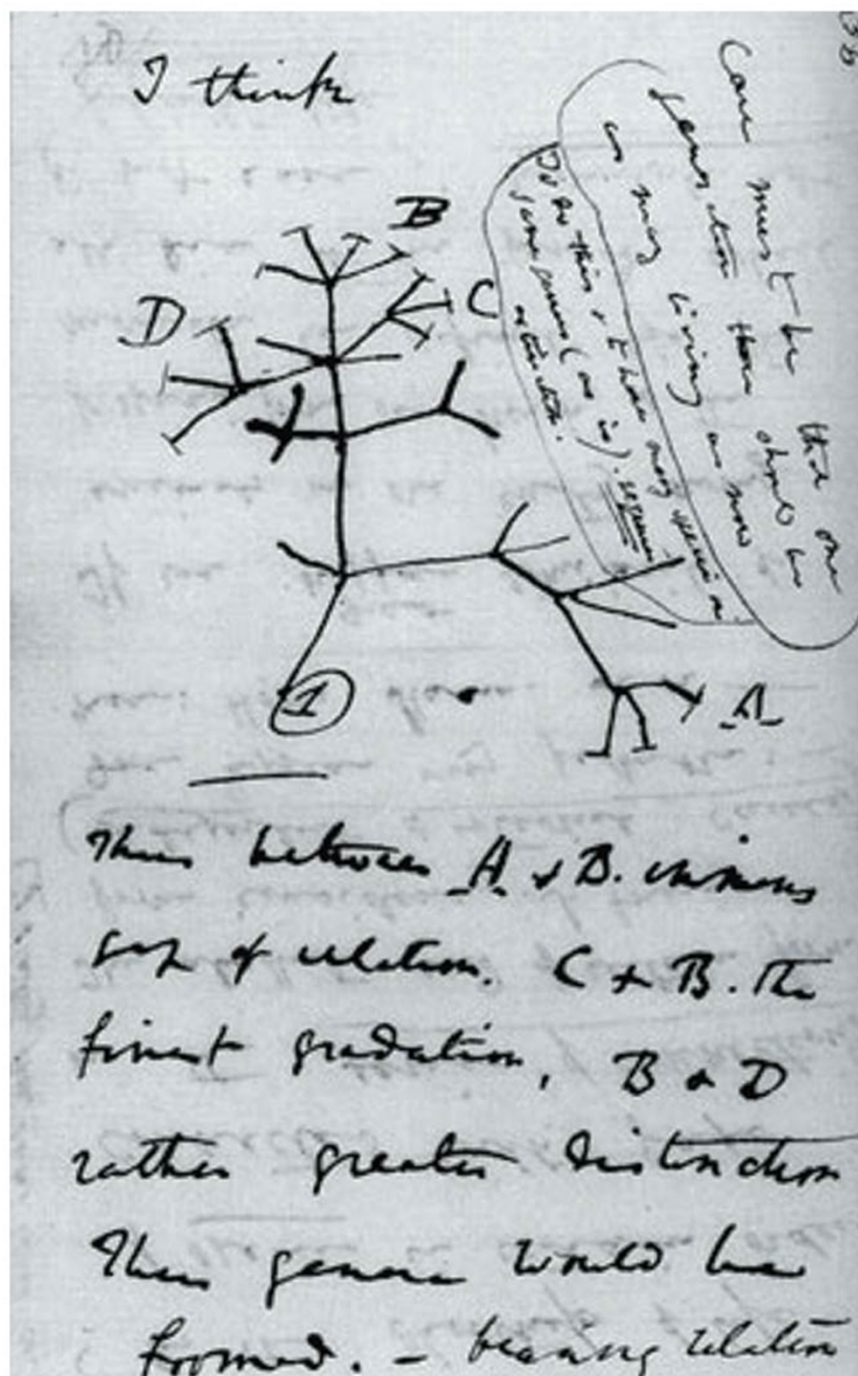
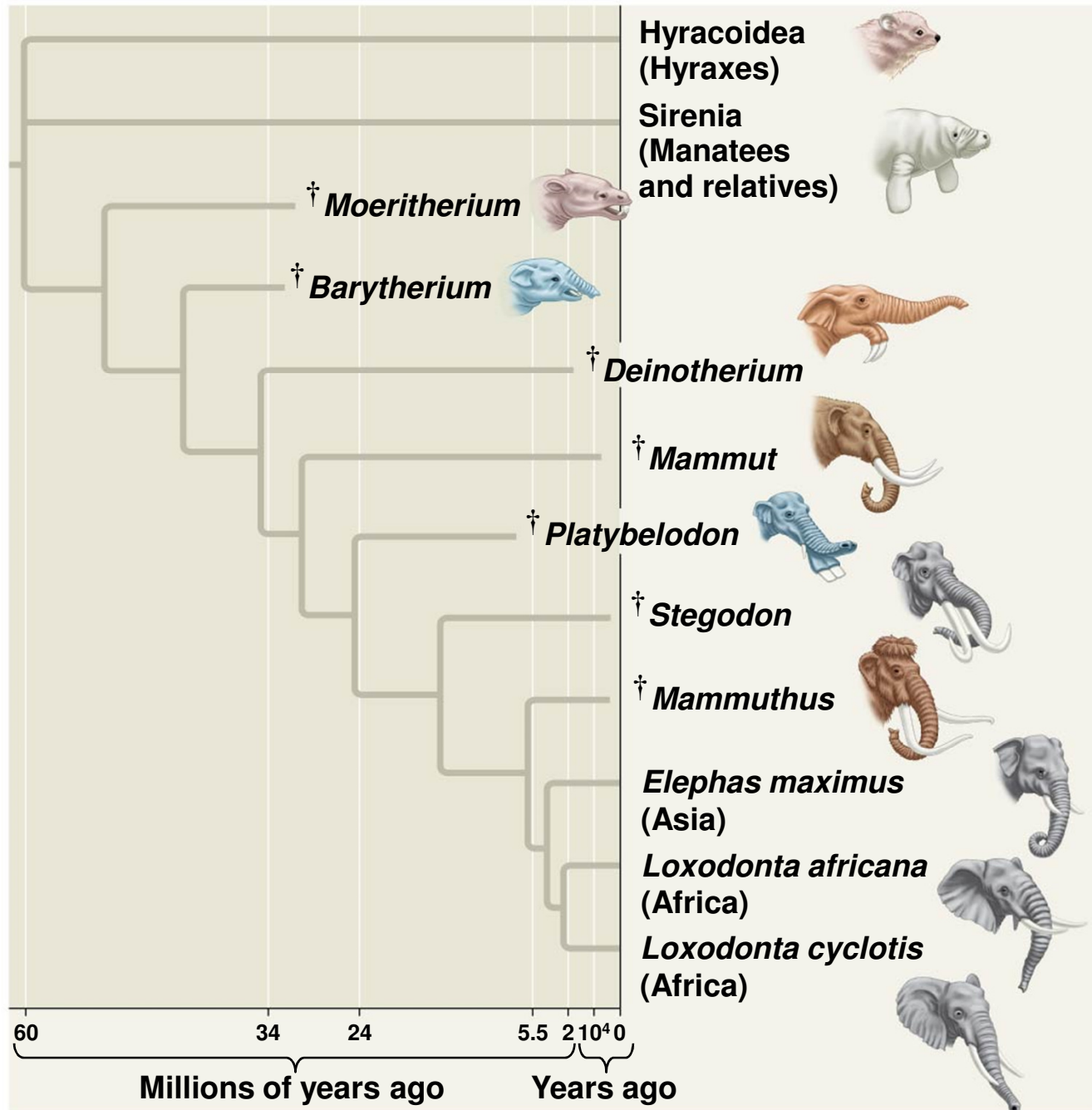


Figure 19.9



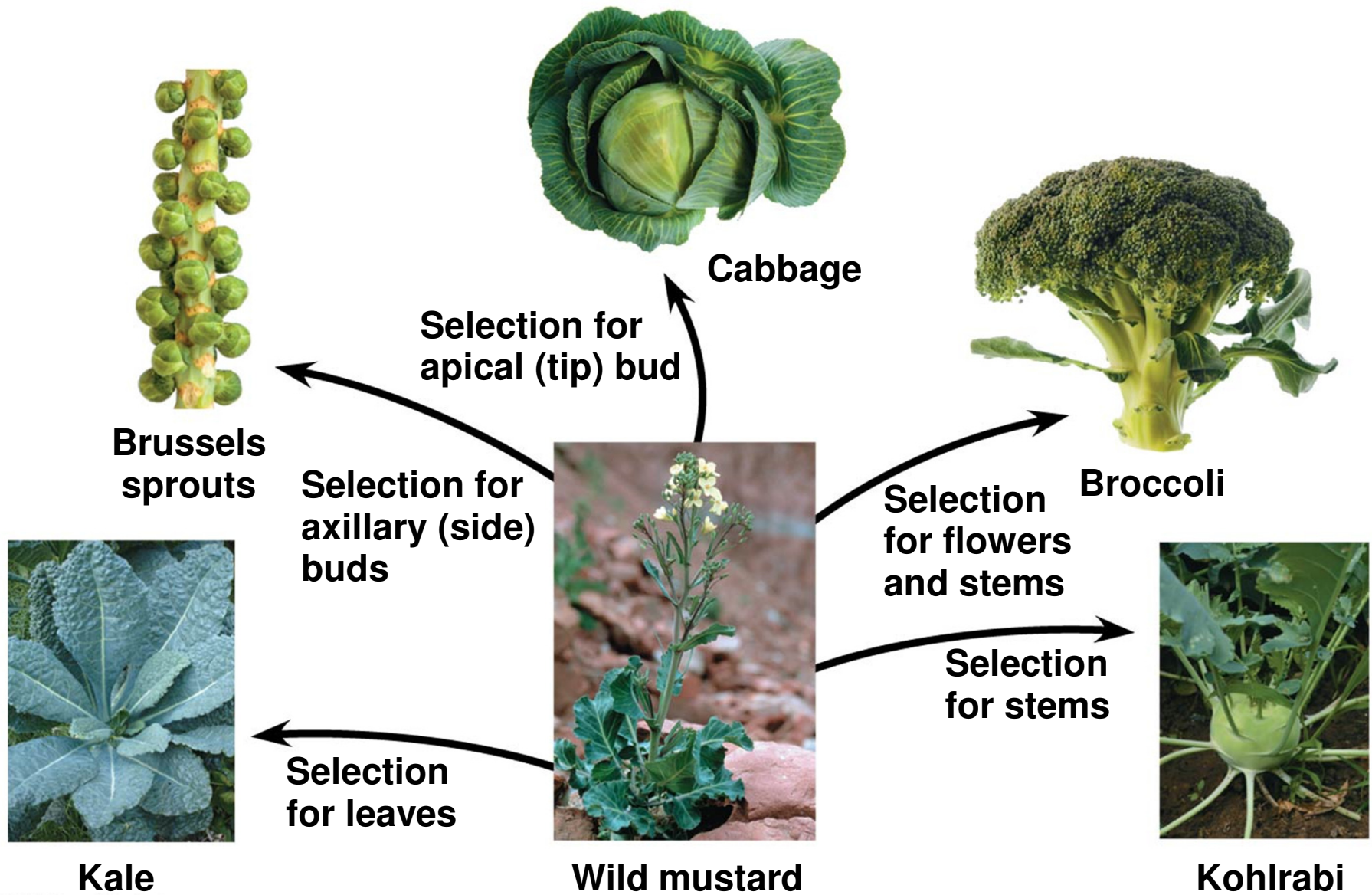
# *Artificial Selection, Natural Selection, and Adaptation*

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- Darwin noted that humans have modified other species by selecting and breeding individuals with desired traits
  - Called **artificial selection**
- Darwin argued that a similar process occurs in nature



Figure 19.10



- Darwin drew two inferences from two observations
- Observation #1: Members of a population often vary in their inherited traits
- Observation #2: All species can produce more offspring than the environment can support, and many of these offspring fail to survive and reproduce



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- Inference #1: Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals
  - Inference #2: This unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations

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- Darwin was influenced by Thomas Malthus
    - Noted the potential for human population to increase faster than food supplies and other resources
  - If some heritable traits are advantageous, these will accumulate in a population over time
    - This will increase the frequency of individuals with these traits
  - This process explains the match between organisms and their environment

# *Natural Selection: A Summary*

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1. Individuals with certain heritable traits survive and reproduce at a higher rate than other individuals
2. Over time, natural selection increases the match between organisms and their environment
3. If an environment changes over time, natural selection may result in adaptation to these new conditions and may give rise to new species

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- Note that individuals do not evolve!
    - Populations evolve over time!
  - Natural selection can only increase or decrease heritable traits that vary in a population
    - If all individuals in a population are genetically identical for a trait, evolution by natural selection cannot occur
  - Adaptations vary with different environments

## Concept 19.3: Evolution is supported by an overwhelming amount of scientific evidence

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- New discoveries continue to fill the gaps identified by Darwin in *The Origin of Species*
- There are four types of data that document the pattern of evolution
  1. Direct Observations
  2. Homology
  3. The Fossil Record
  4. Biogeography

# Direct Observations of Evolutionary Change

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- Two examples provide evidence for natural selection:
  - Natural selection in response to introduced plant species
    - Correlation between fruit size and beak size of Soapberry bugs
    - Beak size has evolved in populations that feed on introduced plants with fruits that are smaller or larger than the native fruits
  - Evolution of drug-resistant bacteria
    - Ex: *Staphylococcus aureus* is now resistant to penicillin and methicillin (MRSA)



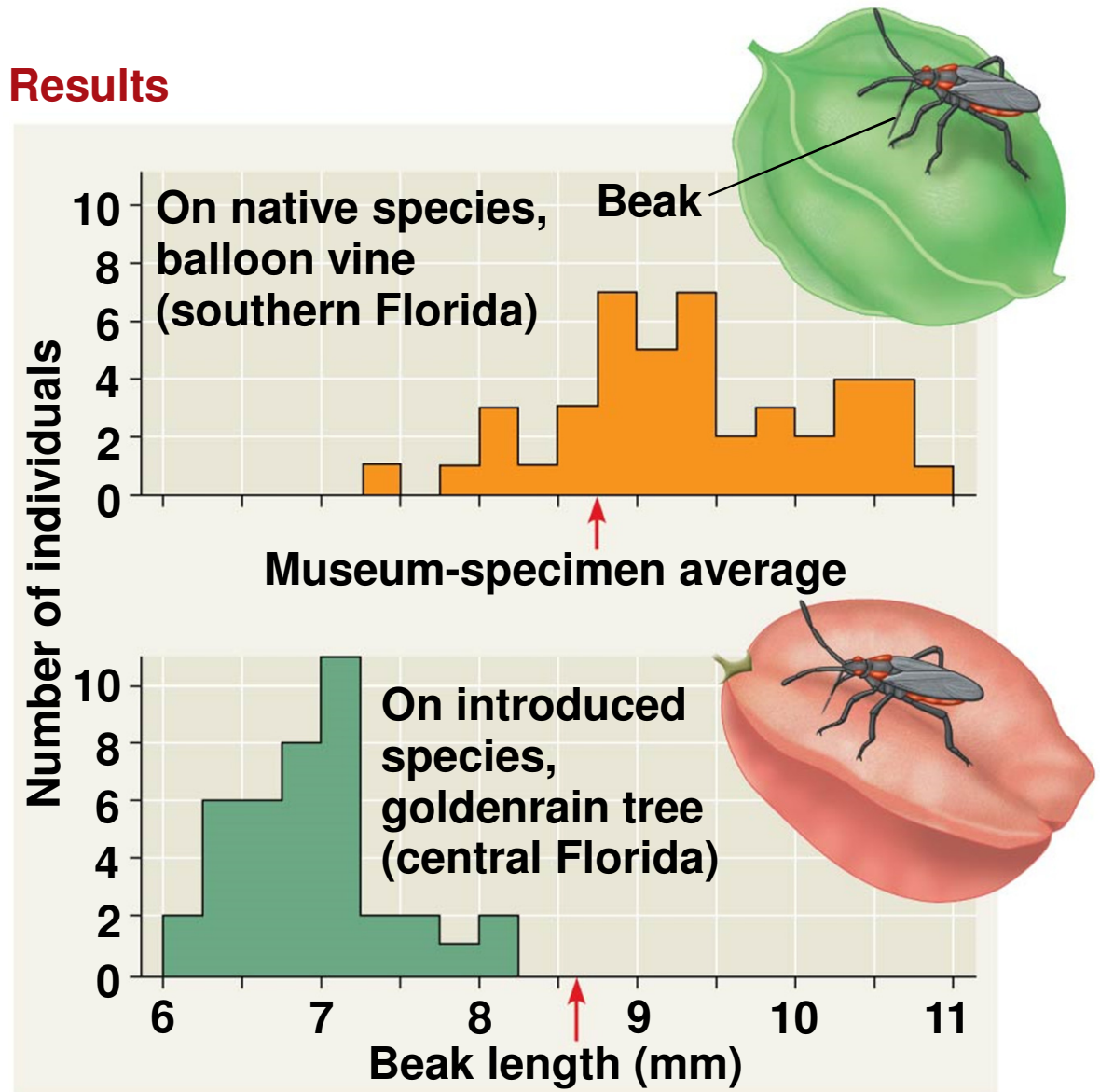
Figure 19.14

## Field Study



Soapberry bug with beak inserted in balloon vine fruit

## Results



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- Natural selection does not create new traits
    - Edits or selects for traits already present in the population
  - The local environment determines which traits will be selected for or selected against in any specific population

# Homology

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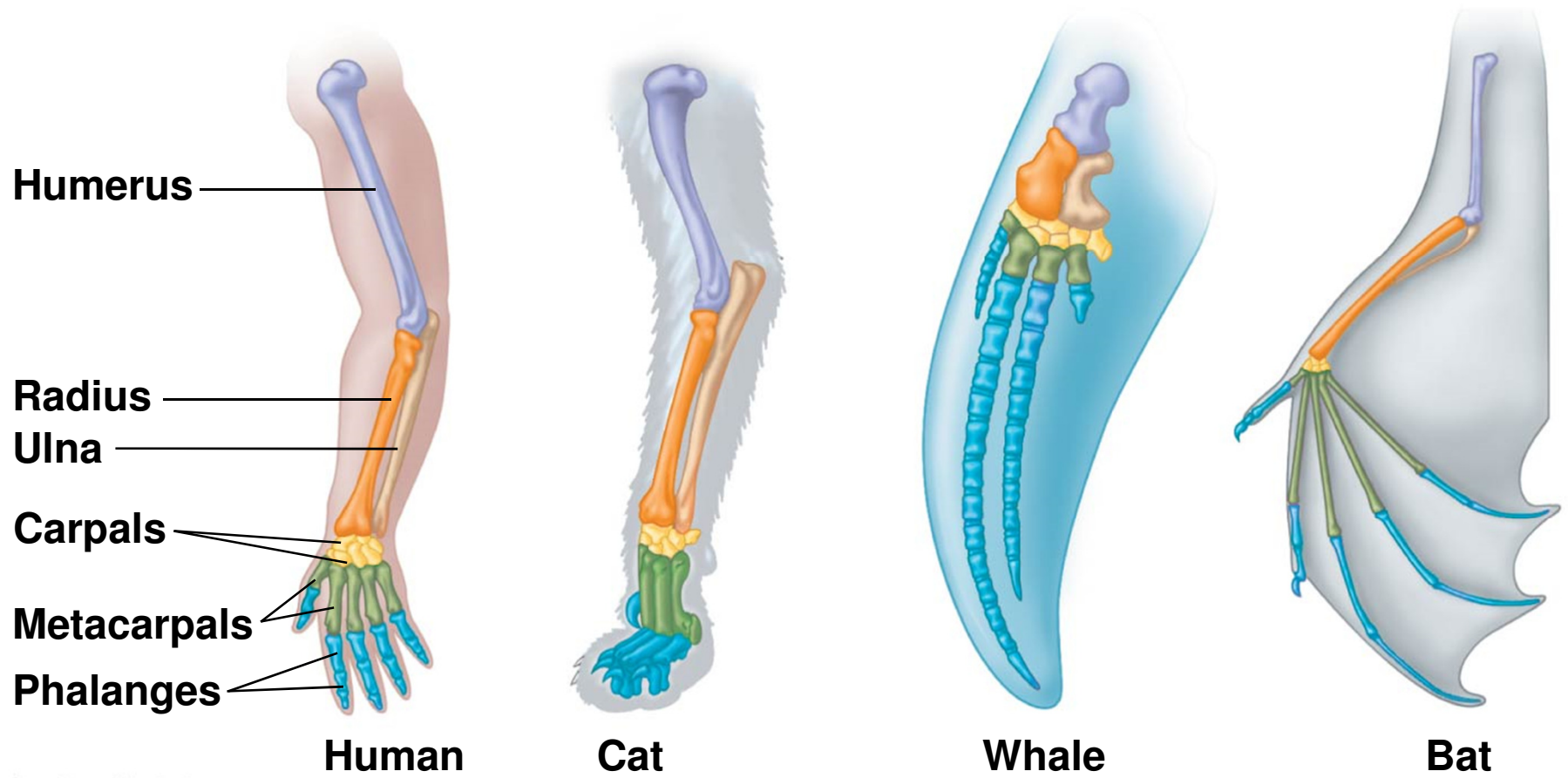
- Evolution is a process of descent with modification
- Related species can have characteristics with underlying similarity that function differently
- **Homology** is similarity resulting from common ancestry

# *Anatomical and Molecular Homologies*

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- **Homologous structures** are anatomical resemblances that represent variations on a structural theme present in a common ancestor
  - Similar structure
  - Function may be different
- *Analogous* structures (wings of bird vs insect)
  - Similar function
  - Not common ancestry
- **Vestigial structures** are remnants of features that served important functions in the organism's ancestors

Figure 19.16



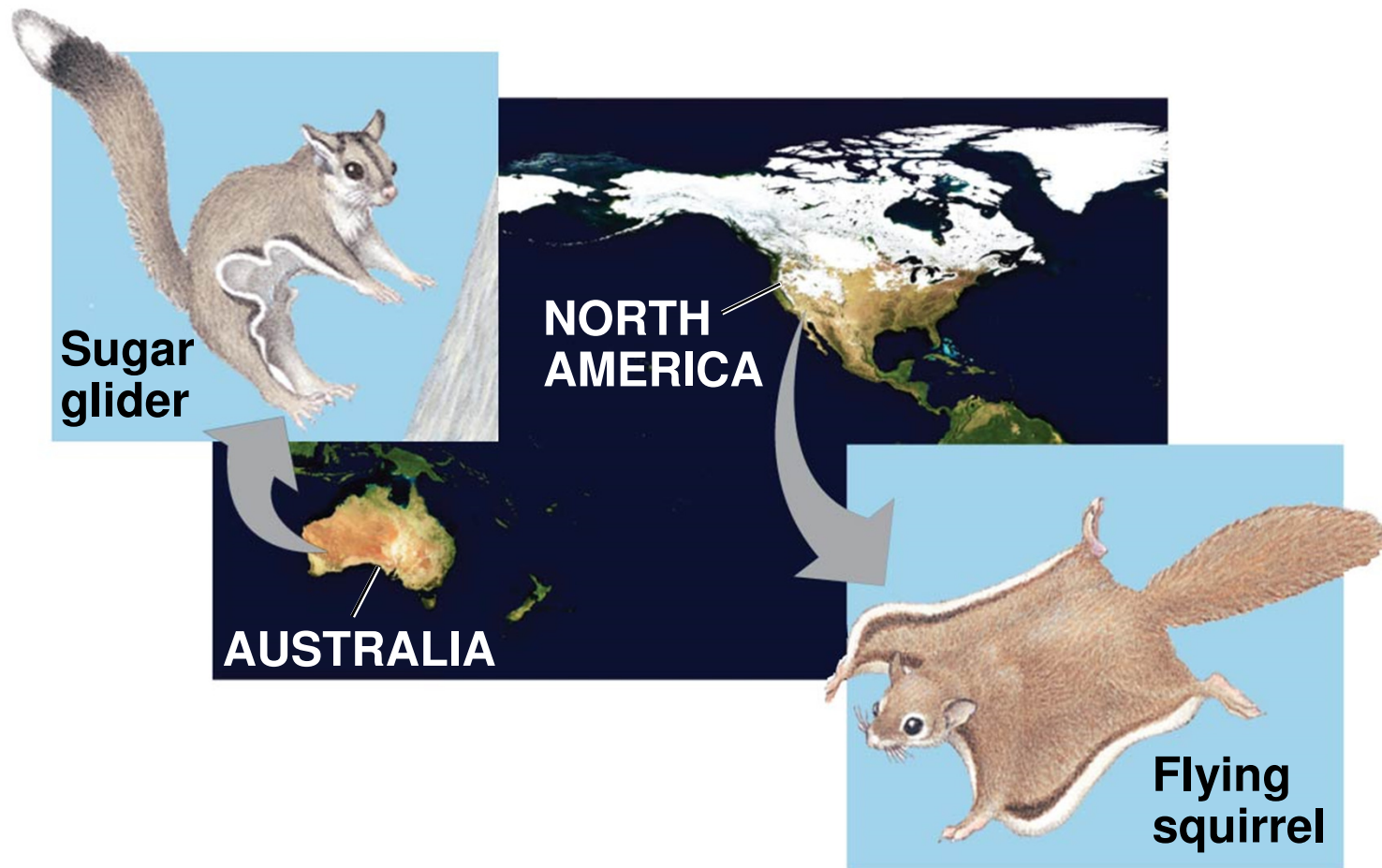
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- Comparative embryology reveals anatomical homologies not visible in adult organisms
  - Examples of homologies at the molecular level are genes shared among organisms inherited from a common ancestor
    - Also, genetic code is universal
  - Homologous genes can be found in organisms as dissimilar as humans and bacteria

## *A Different Cause of Resemblance: Convergent Evolution*

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- **Convergent evolution** is the independent evolution of similar features in different lineages
  - Results in **analogous** traits
    - Similar features in distantly related groups
    - Share similar function but NOT common ancestry
  - Arise when groups independently adapt to similar environments in similar ways
- Convergent evolution does NOT provide information about ancestry

Figure 19.18





# The Fossil Record

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- The fossil record provides evidence of
  - The extinction of species
  - The origin of new groups
  - Changes within groups over time
- Fossils can document important transitions
  - For example, the transition from land to sea in the ancestors of cetaceans

# Biogeography

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- **Biogeography** is the scientific study of the geographic distribution of species
  - Provides evidence of evolution
- Geographic distributions of organisms are influenced by many factors including *continental drift*
  - Slow movement of Earth's continents over time
  - Earth's continents were formerly united in a single large continent called **Pangaea** but have since separated by continental drift
- An understanding of continent movement and modern distribution of species allows us to predict when and where different groups evolved

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- **Endemic** species are species that are not found anywhere else in the world
    - Islands have many endemic species that are often closely related to species on the nearest mainland or island
  - Darwin explained that species on islands gave rise to new species as they adapted to new environments

# What Is Theoretical About Darwin's View of Life?

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- In science, a theory accounts for many observations and explains and integrates a great variety of phenomena
- The predictions of a scientific theory must stand up to continual testing by experimentation and observation
- Darwin's theory of evolution by natural selection integrates diverse areas of biological study and stimulates many new research questions